Solutions for laser processing

Dietikon, 21. Oktober 2019

Bernstrasse 388 | CH-8953 Dietikon | Switzerland
Phone +41 58 856 3011 | www.optotune.com | info@optotune.com
Agenda

- Introduction
  - Dynamic z-axis with EL-10-42-OF lens
    - 2.5D laser processing (with f-theta lens)
    - 3D laser processing (without f-theta lens)
    - Large field laser processing (up to 1x1m scan field)
  - Integration
  - Available products
    - Variable focus inline inspection with EL-16-40-TC lens
Established in 2008
Leader in tunable optics
27 sales partners in 30 countries
~125 employees in HQ, Switzerland
~60 employees in factory, Slovakia
Two major businesses
- Industrial
- Consumer
Privately owned

InVision Top Innovations 2017>
Vision Systems Innovator Award 2016>
Swiss Economic Award 2014>
No. 1 Startup in Switzerland 2011>
Prism Award 2011>
Swiss Technology Award 2010>
Winner of Venture 2008>
ETH Spin-off 2008>
Working principle based on membrane and fluid

Mechanically tunable lens  
Electrically tunable lens

Videos available on [www.optotune.com](http://www.optotune.com)

This information is confidential to Optotune and is not to be copied or forwarded to any 3rd party without our prior written consent.
Conventional laser processing systems can process in 2D using an f-theta lens for field correction.
Laser processing on cylinders, slopes and different levels requires a dynamic z-axis

Extended depth of focus with dynamic z-axis

Laser depth of focus

EL-10-42-OF
Field correction on large scan fields requires a dynamic z-axis
The EL-10-42-OF provides a dynamic z-axis for 2.5D, 3D or large field laser processing systems

<table>
<thead>
<tr>
<th>2.5D: With F-Theta lens</th>
<th>3D or large field: Without F-Theta lens</th>
</tr>
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</table>

![Diagram showing 2.5D with F-Theta lens and 3D without F-Theta lens]
Inline inspection of 3 dimensional parts requires a focus tunable lens to extend the depth of focus.
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• Integration

• Available products

• Variable focus inline inspection with EL-16-40-TC lens
The lens retro-fits in an existing setup

Gaussian beam
6 mm diameter

f = 160 mm
f-theta lens

116 x 116
The lens is placed between the laser and the x-y scanner.
Z-range and spot size depend on the f-theta lens

Focal length of f-theta lens

Larger spot size
Larger z-range
Larger working area
A beam expander allows to adjust the z-range and spot size for further customization.

- **Gaussian beam**: 6 mm diameter
- **f = 160 mm**: Thorlabs FTH160-1084
- **scanning mirror**: +/- 10°

### Diagram:
- **Diverging lens**
- **Converging lens**

Field size (mm):
- 94 x 94
- 116 x 116
- 138 x 138

WD (mm):
- 144
- 191
- 244
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- Variable focus inline inspection with EL-16-40-TC lens
In the absence of the f-theta lens, additional optics are required to focus the laser beam.
3D module available for various configurations
5 lens positions available to realize different field sizes and working distances
A wide range of options available

<table>
<thead>
<tr>
<th>Lens position</th>
<th>Focal length (mm)</th>
<th>Min. scanhead aperture (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>175</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
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</table>

**Similar field size and working distance like with 160mm f-theta (with 1.66X beam expander)**

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<tr>
<td>2</td>
<td>-75</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>250</td>
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**Similar field size and working distance like with 254mm f-theta (with 1.66X beam expander)**

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<td>125</td>
<td></td>
</tr>
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<td>5</td>
<td>250</td>
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**Large field sizes**

<table>
<thead>
<tr>
<th>Lens position</th>
<th>Focal length (mm)</th>
<th>Min. scanhead aperture (mm)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>-100</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1000</td>
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The spotsize is slightly larger but more constant throughout the scan volume without f-theta lens.

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<th>3D module configuration</th>
<th>System specification</th>
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<table>
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<tr>
<th>160mm F-Theta lens</th>
</tr>
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<tbody>
<tr>
<td>System specification</td>
</tr>
<tr>
<td>Level</td>
</tr>
<tr>
<td>Top</td>
</tr>
<tr>
<td>Nominal</td>
</tr>
<tr>
<td>Bottom</td>
</tr>
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</table>
Contact us for support with the optical design or to get the STEP file of the 3D module

Email: sales@optotune.com
Phone: +41 58 856 3000
High speed 3D laser processing with >6m/s on a 45° slope is possible

https://youtu.be/mgvCJt9fMTU
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• Large field laser processing (up to 1x1m scan field)

• Integration

• Available products

• Variable focus inline inspection with EL-16-40-TC lens
Scan field sizes of up to 1x1m with constant spot size can be achieved.

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Laser EL-10-42-OF Fixed focus lenses Scanner
Large field laser processing demonstrated

https://youtu.be/ovj8IAuEmLc
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- Variable focus inline inspection with EL-16-40-TC lens
Integration with the analog EL-E-OF-A lens driver is suitable for 2.5D laser processing (z-stepping)
2.5D laser processing with f-theta lens can be realized with Optotune’s EL-E-OF-A driver.
Very fast 3D laser processing is enabled in combination with the SCAPS Optotune-DSD driver
3D laser processing without f-theta lens can be realized with the SCAPS’ Optotune-DSD driver.
The mechanical holder for the lens needs to provide insolation as the lens is operated at 47°C.
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• Variable focus inline inspection with EL-16-40-TC lens
## 2 lens & 2 driver options available

<table>
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<tr>
<th>Lenses for laser processing</th>
<th>Lens drivers for laser processing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EL-10-42-OF-1064-4D</strong></td>
<td><strong>EL-E-OF-A</strong></td>
</tr>
<tr>
<td><strong>EL-10-42-OF-532-4D</strong></td>
<td>- Analog interface 0-5V</td>
</tr>
<tr>
<td>- Suitable at 1064nm &lt;30W average power (ns &amp; ps pulsed)</td>
<td>- Works with EL-10-42-OF-1064/532-4D &amp; EL-10-42-OF-NIR-4D</td>
</tr>
<tr>
<td>- Suitable at 532nm &lt;1.4mJ (ns pulsed)</td>
<td>- Suitable for z-stepping (2.5D) or large field processing</td>
</tr>
<tr>
<td>- 400 steps resolution on the z-axis</td>
<td></td>
</tr>
<tr>
<td><strong>EL-10-42-OF-NIR-4D</strong></td>
<td><strong>SCAPS Optotune-DSD</strong></td>
</tr>
<tr>
<td>- Suitable from 950nm to 1100nm &lt;30W average power (ns &amp; ps pulsed)</td>
<td>- Digital interface XY2-100</td>
</tr>
<tr>
<td>- 50W version is planned</td>
<td>- Works with EL-10-42-OF-1064/532-4D &amp; EL-10-42-OF-NIR-4D</td>
</tr>
<tr>
<td>- 400 steps resolution on the z-axis</td>
<td>- Suitable for 2.5D (z-stepping), 3D or large field processing</td>
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## Two drivers for the EL-10-42-OF

<table>
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<th></th>
<th>EL-E-OF-A</th>
<th>SCAPS Optotune-DSD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interface</strong></td>
<td>Analog 0-5V</td>
<td>Digital XY2-100</td>
</tr>
<tr>
<td><strong>Controller</strong></td>
<td>Microprocessor based</td>
<td>FPGA based</td>
</tr>
<tr>
<td><strong>Intelligence</strong></td>
<td>Standard PI control</td>
<td>Model based drive algorithm</td>
</tr>
<tr>
<td><strong>80% step response</strong></td>
<td>12ms</td>
<td>8ms</td>
</tr>
<tr>
<td><strong>Demonstrated processing speed on 45deg slope (160mm F-Theta)</strong></td>
<td>0.7m/s</td>
<td>6m/s</td>
</tr>
<tr>
<td><strong>Suitable operation</strong></td>
<td>Z-Stepping for 2D processing</td>
<td>True 3D processing</td>
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• Variable focus inline inspection with EL-16-40-TC lens
Overview

- Z-range of 26mm achieved with -2 to +3 dpt
  - At nominal WD of 144mm (@0dpt)
  - Optical leverage is ~5mm per diopter

- No vignetting

- HFOV of 4mm achieved with 2/3” sensor

- Note: f-theta lens is optimized for 1064nm, while this test was done with red light
Test setup

C-mount camera: UI-3080CP-M 2464 x 2056 @ 3.45um,

Telelens:
- Sill Optics S5LPJ0303 300mm tele lens
- Optotune EL-16-40-TC-VIS-5D-M42
- Sill Optics S5LPJ0303 300mm tele lens

F-theta lens:
Sill Optics S4LFT9263/081 160mm f-theta lens

Test targets with red LED back light
Working distance range of 26mm achieved with -2 to +3 diopters

Optical leverage: ~5 mm per diopter
Magnification changes with 1% per mm from 1.7x to 2.0x over the 26mm z-range
Sample image at 153mm working distance

USAF element: 6/6
Line width (um): 4.38
Lp/mm (object): 114
Magnification: 2.024
Lp/mm (image): 56
Nyquist limit: 145
Pixel size (um): 3.45
Sample image at 144mm working distance

USAF element: 6/6
Line width (um): 4.38
Lp/mm (object): 114
Magnification: 1.889
Lp/mm (image): 60
Nyquist limit: 145
Pixel size (um): 3.45
Sample image at 127mm working distance

USAF element: 6/3
Line width (um): 6.2
Lp/mm (object): 81
Magnification: 1.700
Lp/mm (image): 47
Nyquist limit: 145
Pixel size (um): 3.45